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Research Article

Adaptability of Different *Eucalyptus* Species in Lasta-Lalibela District Northeastern Highland of Ethiopia

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ABSTRACT

The experiment was conducted in lasta woreda Lalibela Debreloza kebele. The main aim of the experiment was to give alternative *Eucalyptus* species for construction and fuel wood over already adapted and distributed *Eucalyptus* species to overcome problems of monoculture *Eucalyptus* cultivation. To do this, the experiment was laid in RCBD with three replications. The species are *Eucalyptus citriodora*, *Eucalyptus grandis*, *Eucalyptus saligna* and *Eucalyptus viminalis*. The data was analyzed by ANOVA with SAS Vr.9.3 via growth performance of different species. The result revealed that, two species (*Eucalyptus viminalis* and *Eucalyptus citriodora*) had shown good performance in root collar diameter, height growth increment and survival rate. The *Eucalyptus grandis* and *Eucalyptus saligna* had shown low performance. Both in root collar diameter and height *Eucalyptus citriodora* was recorded best height (4.03 m), root collar diameter (6 cm) and have good survival rate (47%) followed by *Eucalyptus viminalis*, with mean height of 3.8 m, mean RCD 6 cm and survival rate of 38.9%. Thus, *Eucalyptus citriodora* and *Eucalyptus viminalis* were survive and have better growth performance in highland parts of Lalibela and similar ecologies for fuel wood and construction material in addition to already exist *Eucalyptus* species. These species are the alternative energy source and they are environmentally compatible.

Keywords: *Eucalyptus* species; Adaptation; Highland; Survival rate; Height; Root collar diameter

INTRODUCTION

Eucalyptus plantations cover at least 12 million ha throughout the tropical zone, 90% of which have been established since 1955 [1]. In the 20th century, scientists around the world conducted research with *Eucalyptus* species. They hoped to grow them in the tropics, but most experimental results failed until breakthroughs in the 1960s-1980s in species selection, silviculture, and breeding programs "unlocked" the potential of eucalypts in the tropics. Today, *Eucalyptus* is the most widely planted type of tree in plantations around the world, in South America (mainly in Brazil, Argentina, Paraguay, and Uruguay), Australia, India, Galicia and many more.

The genus was introduced to East Africa in the late 19th and early 20th century and by the early 1970s, the area of eucalypts in Ethiopia, Rwanda, Uganda, Kenya and Sudan had reached 95,684 ha. The largest plantations at that time were in Ethiopia and Rwanda, at 42,300 ha and 23000 ha, respectively [1].

Eucalyptus was introduced to Ethiopia in either 1894 or 1895, either by Emperor Menelik II's French advisor Mondon-Vidailhet or by the Englishman Captain O'Brian. Menelik II endorsed its planting around his new capital city of Addis Ababa. This because of the massive deforestation around the city resulted in shortage of firewood. Plantations of eucalypts spread from the capital to other growing urban centers such as Debre Marqos. The most common species found in Addis Ababa in the mid-1960s was *E. globules*, *E. melliodora* and *E. rostrata* in significant numbers. *Eucalyptus* trees "have become an integral – and a pleasing – element in the Shoan landscape and has largely displaced the slow-growing native 'cedar' Junipers [1].

Eucalyptus species have been highly preferred by the farmers over indigenous or other exotic tree species. Tadele et al. [2] investigation on farmers' species preference in two districts in Ethiopia that in the warm lowland areas *Eucalyptus camaldulensis* is their first choice and in the cold highland areas *Eucalyptus globulusis* their first choice to plant as homestead plantation, private woodlots and in farmland areas. Similarly, *E. globules* at highland and *E. camaldulensis* at mid and low land are the common *Eucalyptus* species that have been dominantly planted in most part of the region. However, if diseases or other environmental problems are breakout on this species, almost most Part of the country remains bare land or the advantages for fuel wood and construction will lose. Therefore, to increase alternative energy source and secure sustainable use Identifying and adapting different *Eucalyptus* species is very much important. Thus, this field experimented mainly focused to select best performing *Eucalyptus* species in the highland parts of Lasta-Lalibela district, northeastern highlands of Ethiopia.

RESEARCH METHODOLOGY

The study was conducted from 2003 E.C. to 2007 E.C. at Debreloza, Northern side of Labella, northeastern Ethiopia. The district is geographically located at 12°35'31'' N Latitude and 39°04'30'' E longitudes.

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The Altitude attains up to 3600 m a. s. l. The district has one cropping season. Mean annual rainfall is 750 mm. The annual mean maximum and minimum temperatures are 14.5°C and 26.7°C, respectively. The soil is classified as Vertisol.

Seeds of selected *Eucalyptus* species (*E. citriodora, E. viminalis, E. saligna* and *E. grandis*) was purchased and raised in Lalibela (Medagie) nursery site. The experiment was laid out in random complete block design with three replications based on soil fertility gradient. Depending on the potential of the selected experimental site, the space between seedlings in a plot was 1.5 m and the space between blocks and plots was 2 m and 1.5 m respectively. Each plot would have about 12 seedlings. Half-moon water conservation structure was constructed. The used material for this study was seedlings of different *Eucalyptus* species; polyhene tube, caliper, and meter were the major tools. The data RCD, DBH, height and survival rate were taken in every 6 month. Data analysis was carried out by one-way analysis of variance (ANOVA) on height, root collar diameter and survival rate of different species

RESULTS

There was significance difference between different *Eucalyptus* species in height ($p < 0.047$) and root collar diameter ($p < 0.042$). However, there was no significance difference between difference ($p > 0.755$) *Eucalyptus* species in survival counts. *E. citriodora* recorded the highest height, root collar diameter and survival rate followed by *E. viminalis*. The least in all growth parameter was *E. grandis* except it has better survival rate (Table 1).

The graph shows the height growth trends of *Eucalyptus* species after planting. It is obvious that, the height increase with growing year. There was slow growth from establishment to one year; fast growth of height was between 12 month and 15 month. Then there was slow growth. Generally, the height growth is dynamics that is in some growing month there was slow and in some, there was fast. This is due to moisture stress. That means the data was taken two times a year so, sometimes data was taken at dry season (Figure 1).

The trend of survival rate was reverse with growing year. That means seedlings were dying in time. In general looking there was high loss of seedling after 15 months. The cause for high seedling loss is some unknown disease that attacks the root of the seedling. In addition, most seedlings were loss during dry season that is due to moisture stress (Figure 2). The diameter growth was very slow still two years after establishment then increases fast still the final data collection (Figure 3).

DISCUSSION

Height of the species

There was significant different ($P < 0.047$) between different *Eucalyptus* species in mean height of the species in four years. That means the null hypothesis was rejected, therefore environmental condition affects adaptation growth performance of different *Eucalyptus* species. In four years, growing season *E. citriodora* (**4.3m**) and *E. viminalis* (3.7 m) recorded

Table 1: Mean height, root collar diameter and survival of *Eucalyptus* species.

Species	Height[m]	Root Collar diameter[cm]	Survival rate [%]
Eucalyptus citriodora	**4.03 ± 0.5^{A}**	**6.5 ± 0.8^{A}**	**47.1 ± 22^{A}**
Eucalyptus viminalis	3.7 ± 0.8^{AB}	6 ± 1.6^{AB}	39 ± 12.7^{A}
Eucalyptus saligna	3.2 ± 0.2^{ABC}	5.7 ± 0.2^{ABC}	37.5 ± 12.7^{A}
Eucalyptus grandis	2.6 ± 0.15^{BC}	4.14 ± 0.5^{BC}	30 ± 12.7^{A}
Mean	**3.4**	**5.4**	**41.25**
CV	15.7	16.7	26.6
Significance (0.05)	**	**	Ns

The values that have same letters are statistically significant

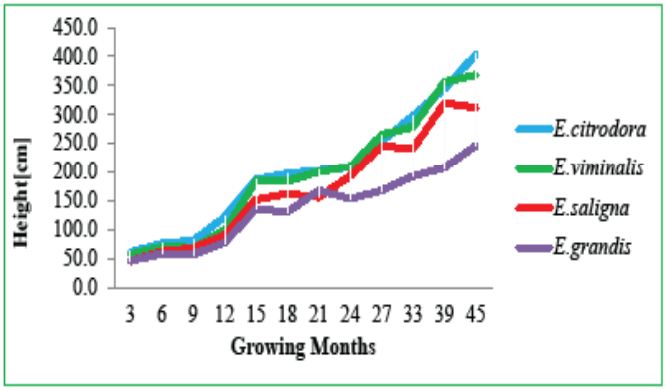

Figure 1: Species height growth trend.

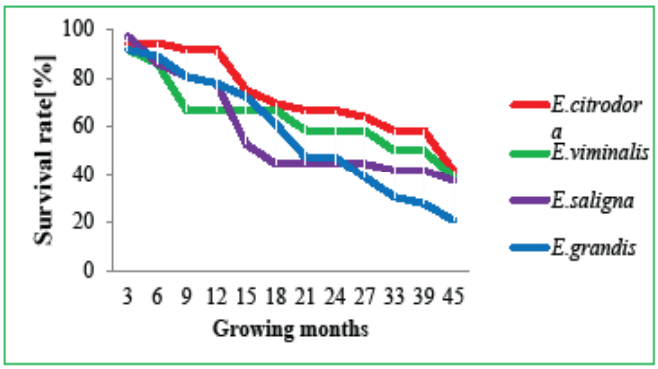

Figure 2: Species survival trend.

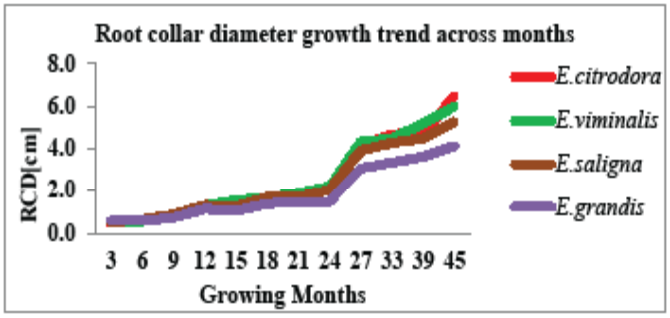

Figure 3: Species root collar diameter growth trend.

the highest height. However, *E. saligna* (3.1 m) and *E. grandis* (2.6 m) recorded the least in height.

E. citrodora has the highest height growth relative to other species. *E. citriodora* has rapid growing upright evergreen broadleaf tree that can reach a height of 50 m tall if leave it on the land for long time. World agroforestry center also reported that the height of *E. citriodora* reached 24-40 m at the age of 16 years based on 1.99 growth rate [3]. The growth rate of *E. citrodora* in this study was 1.1 m per year that means in 16 years *E. citriodora* reaches 17.6 m. This difference is may be from site match, that means our site has minimum annual rainfall and the planted area is degraded (out of productivity). While the origins of the species Australia (Queensland) is the origin of most *Eucalyptus* species.

Cappa et al. [4] in Australia conclude that *E. viminalis* reaches at a height of 2.25 m in two years. This is almost similar 3.7 m in 4 years with this study. World agroforestry center reported that *E. grandis* attains a height of 45-55 m, usually with an excellent trunk and a wide-spreading at age of 25 years in Australia, but in our site the height of this species shows least 2.47 m in 4 years, that means in 25 years it reaches at a height of 15 m [5]. Whitesell et al. [6] in USA at age of 6 years *E. saligna* reaches at a height of 5.07 m, which means the growth rate is 0.85 m per year. Our result shows 3.12 m in at the age of 4 years, that means the growth rate is 0.8 m per year. The result of the two is similar in height and growth rate also. In terms of

height growth trend, the pick growth of *E. citriodora* and *E. viminalis* is after 24 growing months. Other species were grown slowly (Figure 1).

Root collar diameter

There was significant difference (P<0.042) between *Eucalyptus* species in mean root collar diameters of the species. That means in on our study site horizontal wood increment is affected species difference. In 4 years growing season, *E. citriodora* (6.5 cm) and *E. viminalis* (6 cm) recorded the highest root collar diameter. However, *E. saligna* (5.67 cm) and *E. grandis* (4.14 cm) recorded the least in root collar diameter. Species data sheet [7] and World agroforestry center reported that *E. citriodora* have 0.6 m-1.3 m diameter up to its life span. Our result in 4 years shows 0.65 m that is similar result if we take the minimum diameter. According to Cappa et al. [4], in Australia *E. viminalis* reaches 0.02 m diameter in two years. In 4 years the root collar diameter of *E. viminalis* at our experimental site shows 0.06 m, thus our result shows the best performance in diameter. Based on Whitesell et al. [6], USA at age of 6 years, *Eucalyptus saligna* have 0.03 m diameter. In our site it have 0.04 m root collar diameter in 4 years ago that is best from the provenance of USA at age of 6 years. Myers et al. [8] explains in three growing years *E. grandis* receive 0.085 m diameter in Australia. Our result shows 0.04 m root collar diameter in 4 years growing, this difference is because of rainfall intensity and distribution and soil condition differences.

Survival rate of the species

There was no significant difference (P<0.1755) in mean survival rate between different species. All the four *Eucalyptus* species we have tested have almost same survival count ranged from 37% to 48%. However, *E. citrodora* survive best (47.13%) followed by *E. viminalis* (38.9%) and *E. grandis* (41.4%) and *E. saligna* (37.5%) show low survival rate. Of course, this difference comes from growth rates of the species that depends on the genetic, climatic, edaphic and management factors. Whitesell et al. [6] explains *E. citriodora* is a wide adaptable species, grows in a range of soils and moderate drought and water logging tolerance but, it is susceptible to foliar and sap sucking insects [7]. In our study site, there was unknown insect that damage the stand but *E. citriodora* resist the insect attack and survive better. World agroforestry center sets the physical limits of *E. citrodora* that is 0-1600 m altitude, 17-24°C mean annual temperature: 650-1600 mm mean annual rainfall. It is tolerant of a variety of soils, but commonly found on poor, gravelly soils, Podsols and residual Podsols of lateritic origin, and prefers well-drained but somewhat gravelly subsoil. This physical limit is all most similar to our study site, but at the age of 3 years termite and unknown insect minimizes the survival rate. Until to 3 years after establishment, the survival rate of two species (*E. citriodora* and *E. viminalis*) was 80% survival rate. Thus, the low survival is not physical limit rather insect attacks.

E. viminalis has 33.38% survival rate next to *E. citriodora*. It is moderate drought tolerance once established, grows satisfactorily with no obvious signs of stress in a dry summer and low tolerance of compaction. The physical limits of the species are that 38-3684 m.a.s.l. and mostly sand to clay loam and it is mostly adapted semi-arid to normal agro-ecology. In *E. viminalis,* has 62.4% survival rate at the age of 6 years [4]. In our study site, in 4 years it survival reaches 33.38%. The difference is may be insects and pest attacks at age of 3 years and minimum soil compaction, but ecological limit is not that much difference.

The *E. grandis* was highly attacks by pests at age 4 years. Because of this, survival rate was the least when we compared to other species. Browsing by wallabies, particularly black wallaby and the red-legged pad melon can seriously affect height increment and even cause death of young plants. Young trees of *E. grandis* in the 2 years after planting are extremely susceptible to termite attack where they occur [9].

CONCLUSION AND RECOMMENDATIONS

Based on our findings the height and root collar diameter of *E. citriodora* was best relatively compared to others and the second was *E. viminalis*. The main reason for decreasing of survival rate of most species was termite and other some unknown insects. Therefore these different *Eucalyptus* species, have significance different in mean height and mean root collar diameter, and not significant different of mean survival rate. At the beginning 3 to 27 months, all *Eucalyptus* species had good performance. However, when month increases the survival rate of this species was decrease. This difference comes from the difference of specie, their adaptive capacity and interaction with test environment.

The main reason for decreasing of survival rate was termite and other unknown insect and pests. This unknown insect and pest attacks the stem and root of the tree. The stem and the root of the tree bleed black liquid and then dry the whole tree. *E. citriodora* has multipurpose tree for high quality and quantity honey production, for pulp production in low land and mid altitude areas, timber for construction, essential oils, medicine and for intercropping with maize and sorghum. The survival of this species is also the best from other species relatively. *E. viminalis* also uses for essential oil, hard wood timber and medicinal use and it has best survive in our study site next to *E. citriodora*. Therefore, for highland and similar ecologies of Wag-Lasta use these two species (*E. citriodora* and *E. viminalis*) for fuel wood, construction and reforestation purposes.

Further research about disease, insect and pest resistance *Eucalyptus* species, their potential of essential oil, timber and pulp production is required. In addition, our study is only on one site, thus provenance and variety trail of *Eucalyptus* in multi-location is required.

REFERENCES

1. Gessesse DTE. FAO: *Eucalyptus* in East Africa: Socio-economic and environmental issues. 2011: p. 42.
2. Tadele D, Assefa A, Teketay D. Effect of *eucalyptus camaldulensis* and conversion into crop production on growth and yield of maize: The case of Koga Watershed areas in North Western Momona. Ethiop J Sci. 2014; 6(1): 58-69.
3. World Agroforestry Center. *Eucalyptus citriodora.* 2009:1-5.
4. Cappa EP, Pathauer PS, Lopez GA. Provenance variation and genetic parameters of *Eucalyptus* viminalis in Argentina. Tree Genet Genomes. 2010; 6(6):981-994.
5. World Agroforestry Center. Myrtaceae *Eucalyptus grandis* Hill ex Maid. 2009; p. 1-5.
6. Whitesell CD, DeBell DS, Schubert TH. Six-year growth of *Eucalyptus saligna* plantings as affected by nitrogen and phosphorus utilizer. 1988.
7. Species data sheet. *Corymbia citriodora*. 2013; 1:2005.
8. Myers BJ. Plantations irrigated with effluent. 1996: pp. 37644-37653.
9. Skies K, Technologies L. Antimicrobial activity of *Eucalyptus citriodora* essential oil. 2008.